Broadband communication network provided with media storage

FIELD OF THE INVENTION

This invention generally relates to distributed systems and more particularly, to a method and apparatus for allowing communication in access networks along subscribers' lines.

BACKGROUND OF THE INVENTION

At the present, Digital Subscriber Line (DSL) service is offered by telecommunication service providers mainly for the application of broadband Internet access. The service utilizes the copper wires originally deployed for telephony services, to connect customer premises (CPE) DSL modems, and a central office Digital Subscriber Line Access Multiplexer (DSLAM). In many modern applications the DSLAM functionality is distributed to remote terminals aggregated by an aggregation device located in a centralized location. In the alternative, such functionalities are carried in Passive Optical networks ("PON") by an Optical Line Termination ("OLT") that communicates with Optical Network Units ("ONUs") or Optical Network Terminations ("ONTs"). Therefore the term "DSLAM" as will be used herein should be understood to encompass any such device which is operative to receive traffic from the network side at a first bandwidth and convey traffic towards the subscribers wherein the traffic that can be conveyed to the different subscribers has an aggregate second bandwidth, and wherein the second bandwidth is substantially higher than the first bandwidth. Therefore, devices characterized by having current DSLAM architecture, as well as OLT devices and also a plurality of remote terminals and their respective aggregation devices, as a single virtual unit, should all

be understood to be encompassed under the term DSLAM as will be used hereinafter.

Recent advances in modulation technologies allow higher rates of transport over DSL lines. Further, competition on telecommunication services drives local service providers to deploy more services such as video over IP (IP-TV) and voice over IP (VoIP) over the same DSL infrastructure.

The IP-TV service is offered to consist of various capabilities in order to successfully compete with traditional analog cable, digital cable, and digital satellite broadcast. These capabilities include features such as basic broadcast channels; premium broadcast channels; video on demand ("VoD"), Personal Video Recording ("PVR"), etc.

VoD solutions are currently delivered via special equipment used for storing the content that can be provided on demand to the users. Originally, VoD servers were developed as a centralized disk array which holds all the content and is able to distribute to all VoD users simultaneously over a high bandwidth connection, typically available over cable (CATV) networks. Direct Unicast connections between users and the VoD server demand high bandwidth allocation in the broadband networks. To lower this bandwidth demand, distributed VoD solutions, located closer to the users, are offered.

PVR is a video storage application, mostly provided as an integrated feature in the users set top box ("STB"). Few solutions exist that offer PVR as a network service using similar technologies to VoD.

Most digital TV services are offered such that all streams are multicast at the network headend to a single, high bandwidth stream. When a user selects a specific broadcast channel, one element in the network is used to separate this channel from the multicast stream and transmit it to the user over a limited bandwidth

connection. In IP-TV over DSL applications, the DSLAM is typically used for that purpose, hence the need to optimize the network bandwidth requirements from the DSLAM to the broadband network.

An inherent problem with channel change of digital video streams is the average delay created in the video decoder (typically located at the user premises), until a video signal is sent to the television set. To overcome this limitation, several solutions were proposed.

One solution is described in US 6804825, which discloses a method of operating a video on demand system by which a user-requested video program is presented at the user's terminal, after being transmitted over a first transmission channel. In response to a user action, the transmission is interrupted and in response to a subsequent action, the transmission is resumed over a second transmission channel different than the first, while automatically retuning the client terminal to present the resumed transmission over the viewing channel.

US 6748481 describes an appliance for handling streaming (video/audio) information received via Internet by writing blocks in circular buffer. The information appliance includes a buffer, a writer module which receives blocks of streaming information and writes the blocks to the buffer at a write position, and a reader module which selectively reads the blocks from the buffer at a read position. An adjustment mechanism adjusts the relative positions of the read and write position.

In summary, different applications require the use of video storage technologies close to the edge of the network, and in proximity to the DSLAM.

SUMMARY OF THE INVENTION

In order to solve the above described problems, one of the objects of the present invention is provide a

solution to incorporate the video storage sub-system, supporting the VOD, network PVR, and fast channel change applications to be integrated with the DSLAM framework. The DSLAM is enhanced to include local prioritization mechanism as specified by the applications utilizing the video storage device.

According to a first embodiment of the present invention there is provided a DSLAM comprising:

a network side interface adapted to receive a plurality of communication signals conveyed along a broadband network;

a storage means adapted to receive at least some of the plurality of communication signals, associate a priority, preferably by using selection criteria, with the communication signals received thereat and store their content in accordance with the associated priority;

multiplexing means operative to retrieve the content stored in the storage means and multiplex the content thus received with run time data received at the network side interface, into a multiplexed product, wherein this step of multiplexing is carried while ensuring a minimum pre-defined quality of service for the multiplexed product;

a subscribers' output interface adapted to receive the multiplexed product from the multiplexing means and forward it along a communication line extending towards a subscriber; and

a subscribers' input interface adapted to receive information generated by the subscribers.

In accordance with a preferred embodiment of the invention, the retrieval of content stored in the storage means is carried in response to information (e.g. command) received from one or more of the subscribers.

According to an embodiment of the invention, the pre-defined quality of service is determined based on a

type of application by which the content of the multiplexed product is characterized.

By yet another embodiment of the invention, the priority associated with the communication signals is based on a type of application by which the contents of the communication signals will be utilized.

Preferably, the communication signals are selected from the group consisting of: data signals, video signals, unicast video signals, multicast video signals, facsimile signals, audio signals, voice signals and any combination thereof.

In accordance with yet another embodiment, the subscriber's output interface is further adapted to forward the multiplexed product in accordance with a bandwidth associated with the subscriber's communication line.

By still another embodiment of the invention, the subscriber's output interface is further adapted to forward the multiplexed product in accordance with priorities associated with one or more of the components comprising the multiplexed product. In addition or in the alternative, the subscriber's output interface is further adapted to forward the multiplexed product in accordance with a priority that is assigned to the multiplexed product, preferably by the multiplexing means.

According to another preferred embodiment of the invention, implementing personal video recording (such as PVR or DVR) in the DSLAM is done by storing part or all of multicast broadcast video streams based on the subscriber's commands.

In accordance with yet another embodiment of the invention, the multiplexed product is a video stream adapted to be shared by a plurality of subscribers.

By still another embodiment of the invention, the storage means is further operative to allocate storage

space to store certain amount of content for each of the communication signals that are stored.

Preferably, the multiplexing means is further adapted to classify the multiplexed product in accordance with pre-defined criteria and assign the priority for the multiplexed product in accordance with that classification. More preferably, the priority is assigned so as to assure a minimum quality of service required for the type of classification associated with the multiplexed product. In addition or in the alternative, some or all of the bandwidth limitations existing along the communication line that extends towards the subscriber, effect the priority assigned to the multiplexed product.

In accordance with yet another embodiment, the DSLAM further comprises a storage adapted to hold a plurality of multicast video signals and identify at least one of the multicast video signals that is in conformity with information generated by a subscriber (e.g. a command initiated by a subscriber using a remote control to convey that command via his/her set top box towards the subscribers' input interface. Such a command can be for example a change in the channel being viewed).

In addition or in the alternative, the DSLAM is further adapted to unicast the at least one of the video signals identified, to the subscriber generating the information.

According to yet another embodiment, the DSLAM of the invention is further adapted to associate one or more of the video signals stored at the storage means, with a subscriber, and forward the one or more video signals to the subscriber in response to a command received from the subscriber.

By yet another embodiment of the invention, the storage means are adapted to allocate a pre-defined storage space for storing incoming communication signals.

Preferably, the allocation is made in accordance with the type of application by which the content of the incoming communication signals is characterized (e.g. the video streams). Still preferably, after having the allocated storage space filled, any further information that should be stored at that storage space, shall replace the oldest information stored at the allocated storage space. In other words, according to this embodiment content is stored in the allocated space for x units of time and thereafter, as in a FIFO mechanism, the oldest information will be replaced with the new information.

BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention is obtained when the following non-limiting detailed description is considered in conjunction with the following drawings in which:

FIG. 1 illustrates a schematic presentation of a prior art DSLAM and its incorporation in an access network;

FIG. 2 illustrates a schematic presentation of a DSLAM constructed according to an embodiment of the present invention;

FIG. 3A shows a schematic presentation of a prior art network while FIG. 3B shows a schematic presentation of a network operative according to an embodiment of the present invention;

FIG. 4 is a flow chart diagram illustrating a method for establishing a communication session in response to user request for new video service, according to an embodiment of the present invention; and

FIG. 5 shows an example of hierarchical level scheme for managing storage of video streams in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Reference will now be made in detail to an implementation consistent with some embodiments of the present invention as illustrated in the accompanying drawings.

Fig. 1 presents a schematic diagram of a prior art DSLAM **2** comprising the following elements (in either centralized or distributed architecture):

Network interface **10** - used to connect DSLAM **2** to service provider network **12** (not shown in this Fig), allowing the exchange of digital signals with that network;

Switching fabric **4** - used to receive digital signals, have them multiplexed and concentrated by lowering the total bandwidth required for sending transmissions to the users. This means that not all bandwidth pre-allocated to the different users can indeed be provided to all of them, all the time;

DSL modems **6** - used to transport the concentrated high rate data over copper wires to the subscribers, and receive transmissions from them.

Let us revert now to Fig. 2, which describes a DSLAM constructed in accordance with an embodiment of the present invention. In this DSLAM, storage **15** is provided, operative to support all media storage applications required for the DSLAM switching and multiplexing sub-system **4**. The actual storage sub-system **15** may be implemented as an internal or external part of the DSLAM. The storage sub-system of this example, is a digital media (for voice, video, data signals) storage (DMS) server integrated with the DSLAM of the broadband transport system.

Through the network input interface **10**, various inputs of media content such as voice streams, single video streams, multicast video streams, and data streams are received from the broadband transport network, while network output interface **10** is operative to multiplex

media content from the DMS for transmission towards the network, for applications such as video file sharing among users.

The subscribers' side media output interface is operative to multiplex the media content stored in the DMS and sent to subscribers along with the real time data transmitted to the subscriber, along the same subscriber line. The subscribers' side media input interface is operative to receive media content from the subscribers and store it in the DMS.

Preferably, the storage sub-system is further provided with an internal bandwidth and storage broker controller setting bandwidth and storage space priorities to each of the different media storage streams.

Typically, a processor is used to control the overall operations of the DMS.

The DMS of the present example has a built in stream priority mechanism able to assign different priorities to different streams: various media streams stored in the DMS and real time streams sent between the network and the subscriber. Priority is set according to the specifics of each application. This prioritization assures the appropriate quality of service of the stored media streams over the bandwidth limitations available over each subscriber line.

The DMS may be used as a buffer required for the implementation of fast digital TV channel surfing. In such application, the DMS buffers all multicast video streams and is able to uniquely search and send unicast streams immediately after the subscriber changes a channel with no load to the network interface or the broadband network.

The DMS can also be used for the application of network PVR and stores only the content required by the subscriber and allowed by the service provider with no load to the network interface or the broadband network.

This allows the subscribers to have their personal media data stored at the DMS for later use, e.g. upon sending the DSLAM with appropriate command to retrieve their personal media stored and have it transmitted along the corresponding subscribers' lines.

The DMS may also be used for the application of VoD. Most modern VoD systems distribute mostly used titles to disk replicas located at the service provider premises. The DMS (or part of it) can be used for that purpose.

The DMS may further be used for the application of voicemail. If the user uses the broadband access transport system for telephony applications, this feature will be provided with no load to the network interface or the broadband network.

The storage used in the DMS can be made out of the combination of one or more storage technologies. For example, solid state (DRAM, Flash) and/or mechanical disk.

As demonstrated before, part of the capacity of the DSLAM's storage means may be reserved for media content associated with one or more of the subscribers.

Preferably, the storage means is further provided with storage formatting means, operative to allocate different storage sizes according to the media content and/or application to be stored. In addition or in the alternative, the allocation is done in accordance with a service provisioning agreement, pre-signed with the respective subscribers.

Also, according to an embodiment of the invention, at least part of the capacity of the storage is allocated with subscribers (at least with some of them) so that for each of these subscribers, there is a defined and fixed capacity guaranteed.

Furthermore, another option of handling storage at the DSLAM is, that at least some of the storage capacity is gained by utilizing distributed storage means

integrated with the broadband modems that connect the DSLAM with the subscriber, so that in other words, some of the overall DSLAM storage capacity is achieved through the use of memory chips installed on some or all of the modem cards installed at the DSLAM.

Preferably, the DSLAM further comprises backup storage means, operative to backup at least part of the communication signals' content stored at the main storage means. More preferably, the backup storage is further provided with sorting means to determine the communications signals' content that will be stored at the backup storage means in accordance with at least one pre-defined criterion associated with the media content and/or application, e.g. the content of which types applications will be stored. In addition or in the alternative, the sorting means to are operative in accordance with a service agreement pre-signed with the respective subscribers.

When media storage for the applications described above is implemented close to the DSLAM, it is typically located at the local network connected to the DSLAM network interface. As the DSLAM concentrates the streams, some of the data available on the network interface port may be blocked at the DSLAM by the switching fabric and aggregation. To achieve maximum performance, it is required by the applications to set different quality of service (QoS) for each media stream and each application. This is not always possible due to technical limitations or service provider operational constraints. This problem will magnify when many users will demand multiple unicast media storage services such as VoD, PVR, and fast channel change.

As demonstrated in Fig. 2, the media storage input and output streams are directly connected to the DSLAM switching and aggregation functions without any limitation on bandwidth. Using this architecture, the

entire bandwidth load associated with the media storage streams towards the users is relived from the DSLAM network interface and the network connected to it thereafter.

For example, a network PVR can be implemented by connecting the multicast video streams (typically broadcast TV) to the media storage based on user commands. In this implementation, the only unicast connections are set between the user set top box and the DSLAM, hence no increase in bandwidth demands from the network would be required.

Further, the DSLAM can prioritize the media streams utilization of the bandwidth available from the DSLAM to the user premises, thus providing guaranteed quality of service.

Let us turn now to Fig. 3A which shows a typical prior art network, **50**, operative to provide to its end users either multicasting type of services or VoD type of services (where PVR application is considered to be a VoD type of service). The way this network operates, is, by transmitting to the headend the content that should be provided under these two types of services, in response to the end user requirements forwarded via CPE **70**, where it is stored in video server **55**. From this video server, the headend transmits the requested content towards the access network. The VoD type content delivery can be implemented by a direct unicast connection between the video server **55** at the headend and the CPE **70**. Alternatively, to handle large number of subscribers and content, a local replica of the video server **55** is installed in the vicinity of the access network. This replica, consist of a dynamic sub-set of the content stored in the video server **55** is stored at video server **60**. From this server the transmissions will be forwarded per user's demands via DSLAM **65** through CPE **70** to the end user. However, a problem arises as the demand for PVR

type of service is growing fast. Suppose 50% of the end users use the PVR service. This means that at any given moment each of the 50% of the users may get a different transmission than the others. Consequently, even if all the users were to watch, say, the very same film, still, the bandwidth required to fulfill these demands will be extremely high as the various transmissions along the path extending between video servers **55** and **60** will typically be unicast type of transmissions, thus resulting in overloading the network.

The embodiment of the present invention described in Fig. 3B, provides a solution to this problem. By this solution all transmissions will be multicasted to an access video server incorporated with or located at the vicinity of DSLAM **85**. The video server/DSLAM will have adequate storage capacity as explained hereinbefore, and the users' requirements will be met by transmitting stored information to the user's CPE **90**.

This way the problem of overloading the path extending from the headend to the DSLAM while using unicast type of transmissions may be eliminated.

Fig. 4 presents a flow chart exemplifying a method according to an embodiment of the present invention, whereby an example of responding to a user's request for a new video service, is given. The user makes a request (e.g. by sending a command from his/her remote control via his/her set top box) for a new service such view a new live broadcast TV channel, use PVR to record and/or play a unicast or multicast channel, or request for VoD (step **100**). A separate user management system checks if there is sufficient bandwidth allocated for that user so that the request can be fulfilled (**110**) and if not, rejects the request (**120**). If the bandwidth available is sufficient, then the system checks whether this request can be fulfilled by utilizing a TV broadcast (e.g. a channel that is currently broadcasted) (**130**). If in the

affirmative, the DSLAM is requested to set a high priority connection between the user and the multicast stream reaching the DSLAM, and the user may watch the channel of his/her choice (**140**). Next, the system checks if the user requires using a network PVR ("nPVR") (step **150**). An example for such a request could simply be when the user presses the "pause" button on his remote control, which means that the user would like to continue watching the same broadcast channel but with a delay. In this case, the picture will be frozen at the user's TV set, while the multicast stream will be connected the nPVR input (**160**). Thereafter, a virtual high priority connection is set between the end user and the nPVR output stream at the DSLAM, and the content that is broadcasted to other viewers is stored at the DSLAM's buffer. Once the user request to resume the display, he will receive the broadcast from the DSLAM's buffer, while that buffer still continue to store the incoming mulicasted signal. Once the user causes the buffer to become empty (e.g. by skipping commercials, using fast forward functionality, etc.) the buffer capacity is available for use for another user. In this example, if the request is not for nPVR, it is assumed to be a request for VoD, and the system checks whether the requested content is available on the local replica of the VoD server (**170**). If in the affirmative, a direct high priority, unicast connection is set between the user and the VoD server, and the requested content is forwarded to the user (**180**). If not, the requested content is searched and retrieved at another VoD server located in the network, and a network connection is established between the storage means in which the requested content is stored on the local VoD server (**190**), and upon receiving the requested content at the local VoD, step **180** is carried to allow transmission of the requested content to the user.

Fig. 5 presents an example of a management scheme in accordance with an embodiment of the present invention. By this example of a possible quality of service management, the management system checks whether the user storage is partially or completely empty (**200**). In case the storage is full, step **200** shall be repeated after a certain period of time. If the user storage is at least partially empty, the system checks whether a high priority video stream data is available (**210**). Such high priority video data can be related to multicast broadcast video, or unicast stream from the VoD or nPVR storage. If there is such data available, some or all of the data is sent to the user's storage (step **220**), and step **200**, where the occupancy of the storage is checked, is repeated (either immediately or after a certain period of time). If no high priority video stream data is available, the management system checks if there is low priority video stream data available (**230**). Such low priority video data can be related to picture-in-picture presentation or unicast streams associated with fast channel change. If there is such data available, some or all of the data is sent to the user's storage (step **240**), and step **200**, is repeated (either immediately or after a certain period of time). If also no low priority video stream data is available, the management system checks if there is Internet data available (**250**). If such data is available, some or all of the data is sent to the user's buffer (storageuffer or not, step **200** will be repeated either immediately or after a certain period of time.

It is appreciated that various features of the invention which are, for clarity, described in the contexts of separate embodiments may also be provided in combination in a single embodiment. Conversely, various features of the invention which are, for brevity, described in the context of a single embodiment may also

be provided separately or in any suitable sub-combination.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described herein above. Rather the scope of the invention is defined by the claims that follow: